

**Atlantic Salmon Workshop Notes**  
**Vancouver, British Columbia**  
**March 15-16, 2001**

**Introduction-Why this workshop?**

The idea of this workshop came about from concerns regarding the potentially harmful effects the large number of Atlantic salmon (AS) escapees may be having on Pacific north-west and Alaskan marine and aquatic ecosystems. While British Columbia's Atlantic Salmon Watch Program (ASW) was formed to monitor the problem, growing region wide concerns about aquatic farms and escaped AS reports caused an increase the number of participants in the Atlantic Salmon Watch program. The British Columbia (BC) Fisheries agency decided it would be beneficial to bring all affected parties together to share knowledge. It located funding for a workshop for ASW program members in which the present state of knowledge could be presented and potential solutions to information gaps could be developed. The academic community was invited as this contentious issue to provide informed discussion. The goal of the planners of this workshop was to go over the issues regarding AS with as little bias as possible.

The Atlantic Salmon Watch program (ASW) was initiated in 1996. It includes catch monitoring, biological sampling, public education and active stream monitoring. In the year 2000 ASW documented 7,800 marine, 126 freshwater recoveries, making this the highest catch on record. Recovery information is posted on the ASW website at:

<http://www.pac.dfo-mpo.gc.ca/sci/aqua/pages/atlsalm.htm>.

This website contains considerable information regarding the whole ASW program.

**General Information from BC**

**Differentiating wild AS from farmed AS**

- In the past escaped farmed AS consistently displayed fin wear while wild AS do not. This is no longer considered a valid characteristic as some escapees show no obvious fin wear.
- Otolith examination does show place of origin for AS recoveries. Farmed fish have uninterrupted patterns on their otoliths reflecting year-round feeding in the pens while wild fish do not.
- Scales are used to differentiate wild from farmed fish on the Eastern North American Coast but their reported accuracy is only 75-80%.
- Pellets used to feed farmed AS contain different chemicals than is found in natural feed. Testing of carotinoids in recovered escapees may differentiate farmed from wild fish.
- The testing of the accuracy of these identification techniques is underway.

**General Information**

- Less than 5% of recovered AS have contents in their stomachs so over 95% are not feeding after escape from net pens.
- About 30-40% of wild Atlantic salmon (in the Atlantic Ocean) had prey items in their stomachs.
- ASW monitored small sections of 45 freshwater systems in 2000. They recovered 32 adults and 2 juveniles in 5 systems. Adult recoveries were achieved using a pneumatic laser-sighted spear gun which is effective and minimizes disruption to other species. Juvenile recoveries were achieved using a hand held minnow net.
- Adult AS tends to migrate with other salmonids. Sexual maturation of escaped AS seems to be later than Pacific salmon so spawning may also occur later.

- BC production for 1999 was 76% farm and 24% wild. Of all farmed fish 81% were Atlantic, 16% chinook, 3% coho. Chinook and coho salmon also escape from aquatic farms but this problem does not receive the attention AS escapes receive.

#### Report: Ministry of Environment, Land and Parks (MELP) at Nanaimo:

- MELP runs a stream survey program that looks for feral populations of AS. The systems to be surveyed are chosen by proximity to farms and hatcheries or by prior reports of sightings.
- In 2000, MELP surveyed 13 streams and recovered 12 parr and 2 fry. BC's four index streams are the Amor de Cosmos, the Tsitika, the Adam and the Salmon. In the Amor de Cosmos, they recovered juveniles in both 1999 and 2000 indicating a likelihood of feral population establishment.
- Extrapolating from the number of BC streams surveyed that do have rearing AS in them, there may presently be successful AS spawning in 200 BC rivers and streams.
- There is no standardized method of stream survey. One survey does not equal another survey. Expertise of diver, % of stream covered, focus of diver (adult or young) and effort per unit area can vary considerably between surveyed streams.
- Atlantic salmon fry are difficult for the inexperienced to identify. They have large fanlike pectoral fins and small red dots between parr marks. Very often, they are misidentified as Dolly Varden.
- Observed juveniles appear to have benthic orientation in high energy, cobble/boulder substrate orientation and do aggressively maintain territories. Juveniles probably compete for habitat and diet with rainbow trout, steelhead and possibly cutthroat trout. Feral juveniles have survived to at least the parr stage.
- There is evidence of at least one unauthorized planting of AS in BC. Small fish (1lb.) were recovered from May Lake on Vancouver Island which has no outlet.

#### General Discussion

- Fifty-six percent of present BC salmon production comes from farms. The moratorium on new farms is supposed to end this fall. If this happens, the aquaculture industry plans to double production immediately with an eventual 6 to 10 fold increase projected. Economic studies indicate the BC market (western U.S.) could absorb such production.
- Atlantic salmon farming problems on the East Coast include, but are not limited to, the listing of wild North American Atlantic salmon stocks as endangered.
- As a rule of thumb, it is safe to assume that no farmers want sexually mature fish on their farms.

#### Norway experiences

- Norwegian brood stock comes from 27 different stocks. Farm fish are considered less aggressive, less active, display delayed spawning and less hierarchy. Some farm males do not ejaculate even when allowed to spawn. Farmed females defend redds as often or aggressively as wild females do. A study showed that farmed fish display; 1/3rd the breeding success as wild stocks, high juvenile mortality, and 16% lifetime breeding success.
- When farmed fish are present in spawning streams, a 30% depression in wild stock productivity has been measured. This may be caused by the very aggressive nature of juvenile fish from escaped farmed stock.
- Norwegian studies show hybrids between wild and farmed stocks have about 16% of the fitness of wild stocks.
- In Norway, escaped farmed salmon were an estimated 40% of the marine catch several years ago. Now it is estimated to be 20-30% of the marine catch. In the rivers farmed salmon are estimated to constitute a minimum of 5-9%.

- Typical Norwegian stock size is low compared to typical Alaskan salmon stock size. Norway considers a healthy stock to be only several hundred returning adults. How the size of wild Norwegian AS runs have changed since the advent of aquaculture operations was not mentioned.
- It appears that some alleles formerly found in wild Norwegian AS have been lost due to interbreeding with escaped farm stock. This loss is thought to reduce to an unknown degree the genetic fitness of their wild stock.
- Escaped farmed AS are an important resource for the sport fisher in Norway. Numbers of AS are so high in estuarine areas that the typical sport fisher throws gravel in fishing water to draw the escaped farmed AS in.
- The Norwegian aquaculture industry considered a 3-5% loss of stock through escapes and net changes acceptable.
- Norway has a new action plan on escapes but it has yet to be translated into English.
- With the last few weeks, there was a news story that Norway now considers the negative effects of AS salmon farms on wild AS stocks to be so great that it will require some existing farms to be relocated away from areas important to wild AS stock.

#### Disease problems

- Farmed fish, like other farmed animals, may display greatly increased disease and parasite occurrences compared to wild animal populations. This is a function of easy transfer of pathogens within animal concentrations. Such disease problems can infect wild salmonids migrating near aquaculture sites.
- ISA (type of salmon anemia) is moving around the globe through transport of farmed salmon stock other unknown vectors. It can be carried by brood stock even though the fish don't display symptoms.
- High concentrations of sea lice on farmed AS is a serious problem and has likely contributed to the loss of wild stocks of AS in Norway.
- Wild AS smolts typically have <5 sea lice on them. Wild AS smolts caught near farms may have 400-500 sea lice on each which results in smolt mortality.
- The treatment of sea lice infected farmed AS with pesticides has potentially significant negative ecological effects on both benthic and planktonic invertebrates.

#### Escapes

- The BC Aquaculture Review has decided that a small, <5% loss, of farmed AS is permissible. Estimated 'leakage' of BC production is about 3%. which translates into about 350K 'leaked' and escaped fish per year at present production levels.
- The genetic impact of escaped AS on Pacific salmon stocks is thought to be low because AS and Pacific salmon don't interbreed. On the contrary, there is a high potential for genetic impact potential for escaped farmed Pacific salmon.
- In the Atlantic ocean, wild AS males often displace escaped farm males and breed with escaped farm females.
- The historical Atlantic salmon population in the Atlantic numbered approximately 20 million fish. It is now estimated at less than 200K of fish. These numbers are low by Pacific salmon standards.
- In the Atlantic ocean, >99% of all Atlantic salmon are on farms. Farmed salmon form a relatively new stock on the eastern North American coast. Some think AS will likely become a new species eventually on the west coast.
- The salmon farming industry is a potent economic force and is not going away. The industry does need stricter regulations and effective methods for mitigating its impacts.

- The BC wild catch is declining possibly due to habitat destruction, over fishing and global climate change. Unhealthy Pacific salmon populations now provide an environment for invasive species, such as the AS, to become established and compete with native fauna.
- In some laboratory experiments Atlantic salmon demonstrated dominance over steelhead.
- The feed conversion ratio is 5 to 1 for farmed fish and <3 to one for wild fish. Soy protein is an increasingly important component of fish food pellets because most fish meal now goes to chicken feed.
- Fatty acids in fish are considered essential for human brain development. Certain of these compounds are no longer present in farmed fish that are fed vegetable based feed.
- Industry would like to see growth in their industry that is similar to growth in consumption of fish: + 15-20% per year.
- Atlantic salmon currently make up 80% of the fish farmed in the Pacific because of adaptability, food conversion and name recognition.

#### Afternoon Breakout Session into 4 groups:

##### 1) Containment and Escapees

- The actual leakage rate is unknown as discerning mortalities from escapes is challenging.
- Natural mortalities sink in nets and decompose rapidly.
- The fact that farms do not report escapes is considered a serious problem. Incentives to encourage the industry to report escapes must be developed.
- Inventory control protocols to quickly determine escapes must be developed.
- The containment and recovery systems must be improved. Researchers should look at incorporating fiber-optic cable or some sort of wire in netting so that breaks in the net could be detected.
- Inventory control must be improved. A recommended first project is to track several groups of fish through entire process in order to determine total leakage rate.
- There is a need to get a better idea on the causes of escapes and short term behavior of escapees. The latter will suggest better methods for containment of an escape.
- Counting of the number of fish going into the pens is only accurate to about 3% so it is difficult to know the exact number that may have escaped even after final harvest.
- Use of triploid stock would be problematic. They do not grow well being 25-30% smaller size at harvest. Also, a large % of hybrids are deformed or have soft flesh.
- BC is setting up an Aquaculture Research and Development Council. This may be a funding source to develop and improve containment.
- More effective counting devices are needed. As coded wire tag costs 10 cents/fish, the cost of tagging all farmed AS is not prohibitive. The stock could be re-inventoried at each net change and escapee source location identified.
- A significant number of escapes (0-20%) occur during certain parts of the normal farming cycle. To lessen the effects of fouling thus improving water circulation, larger mesh nets are put in place around existing nets when fish generally have grown large enough. Once the outer net is in place, the inner net is opened and removed to free the contained fish. A significant loss often occurs at this time when fish smaller than average, called 'non-performers', simply swim away through the larger mesh. This is looked at as natural culling and is not considered a great loss to farmers because the fish were not growing well. Perhaps unreasonably, no environmental harm is thought to be done as these escapees are considered to have short survival time in the wild.
- Assessment of this loss can be attained or stopped through the placement of a smolt net around the entire operation and counting escapes after the nets have been changed.
- Large scale escapes are often due to anchor failure. Appropriate anchoring technology should be developed. Each farm should be required to have their anchoring system certified.

- Better containment systems should be developed, certified and required.

## 2) Active Monitoring:

- There is a pilot project in BC that is looking at completely closed salt-water containment but no results are in yet.
- Land based AS farming would eliminate all escapes but the cost makes it unfeasible.
- Allowing only the farming of females should be considered.
- While Norway AS escapes are down significantly due to some farms being relocated away from unsuitable sites, this isn't possible in BC due to their moratorium on new sites.
- Farmed fish could be tagged when vaccinated. Tagging might have benefits for farmers too because it would allow them better inventory control (tag detectors could double as fish counters) and they could also track productivity of different stocks.
- Washington State is considering thermal marking of farmed fish. Alaska has great expertise in this area if help is needed.
- **Note 'A'**. Gill netting effort in BC is the chief way AS escapes have been found and monitored in the past. Recently, the number of commercial fishing days has been reduced by 75% making no-cost monitoring for escapes difficult. The catch reporting of AS by gill-netters is considered good as they are allowed to sell AS at a good price.
- **Note 'B'**. Industry claims to have plans for recovering fish in vicinity of catastrophic escape through a torn net but that is questionable. The year 2000 escape of AS in Sergeant Passage was detected by a coincidentally commercial fishery opening taking place. Although 72 seiners and 14 gill-netters were actively fishing in the immediate vicinity of the escape, only about 20% of the fish were recovered. Therefore, the planned for result of designating several recovery boats to stand by in case of an AS escape seem dubious.
- The 20 Atlantic salmon/day BC Sport Fish catch limit comes from generic regulations limiting any non-specified species catch to 20/day - this regulation was not designed specifically regarding Atlantic salmon.

## Behavior

- There is little information about what AS do after escape. It was proposed to release radio tagged AS adults in BC and Alaska to track escapee movement and to investigate behavior. While an interesting idea and would give critical information, getting permission to release AS intentionally would be challenging both in BC and Alaska. Funding for such a project may be available through a Canadian Science Foundation.
- **Conundrum** – It will be challenging to do research on the ecological effects or movements of AS without leaving feral populations in place or intentionally releasing them. A delay in removing feral fish in BC might be possible. There was consensus that it is of dubious value to carry out experiments in closed systems.

## Ecosystem

- No one knows why Atlantic salmon may be reproducing in streams now despite numerous past failures. A few hypotheses could be researched to better understand the problem faced now:
  - The threshold of a self-sustaining population is now being met but was not in the past.
  - Indigenous fish populations are reduced from those in the past thus reducing competition.
  - AS may compete better in highly degraded systems.
- There should be research on marine benthic effects from farms both from increased waste and from pesticide use.

- Many research projects regarding the potential effects of AS on indigenous fresh water species could easily be developed.

### **General Discussion**

- The industry could be required to produce all females. This is done by treating developing fry with methyl testosterone (MT) causing the males to become hermaphroditic. Their sperm to fertilize a second generation of females with all resulting progeny being females.
- Presently, all chinook farmed in BC are females produced using this technique.
- The industry could be required to genetically modify farmed salmon so they are dependent on some trace element unavailable from nature. Escapees would die of trace element deficiency.
- The industry could be required to only raise sterile hybrids.
- Some funding AS research may come from SEAGRANT as Washington State will hopefully become involved. Anecdotal evidence from Washington State is that there may be significant numbers of AS entering their streams. Though invited to this workshop, no one from Washington State was in attendance so their acknowledgment of the AS problem is unknown.
- BC Provincial funding for research/monitoring is uncertain.
- There is a need for an organized industry approach. The BC Research and Development Council could coordinate this effort.
- There may be funding from the Canadian Federal Government for baseline research. A proposal, which Alaska was invited to partner in, has been developed and submitted.

### **Miscellaneous Discussion and Summarization of the day's important points**

- There is a need to set up sampling program on streams where adults/juveniles have been observed to see if smolts are leaving. Size at smolts is an indication of how well the population is doing.
- Vulnerable estuaries and streams must be designated and observed.
- Laboratory work and field observations must be integrated.
- Once more data is collected, predictive models should be developed.
- It is important that intense surveys of systems with feral Atlantic salmon populations be carried out immediately to determine, if possible, what is making colonization possible.
- As resources allow, less accessible streams should be surveyed to locate other feral AS populations.

### **Day 2-Miscellaneous discussion**

- The first confirmed case of ISA in farmed Maine salmon has been reported. Prior infections had been reported in eastern Canada.
- Atlantic salmon escapees recoveries, even those found in fresh water, are usually "bright", freshwater.
- Sport stocking of AS in the U.S is considered to be a problem. Case in point-Oregon still stocks them into Mud Lake in Oregon.
- There are eight farm sites in Washington State. These have been responsible for huge numbers of escapes including; 101K in 1996, 370K in 1997 and 115K in 1998. Both of the later escapes were from the same farm.
- A code of practice is being developed in Washington State and is in place in BC. Not all farms have signed on and there are no consequences for violations.
- Last year's escape in BC was estimated by industry as 32K. This was based on the reduction of the feeding rate post-escape so was likely was many times higher.
- Having a good handle on the number of fish present on a farm is not seen as needed by the BC industry. Most aquaculture companies don't carry insurance on lost stock as it costs about 4% of the value of the stock on-site and has a high deductible.

- ASW checks recoveries for fat content of recovered fish among other things. Fat content is less in Alaska caught fish than for those fish recovered in BC. This may indicate most escaped AS may not be feeding. Scale growth patterns might be useful for determining the length of time since escape as scales from recovered fish show thin and closely spaced circuli at margins.
- Adult AS recoveries from Salmon River in BC show active feeding behavior is common and calls into question assumption that adults would not feed in freshwater.
- Because of falling prices, the value of farmed salmon production dropped from approximately \$500 million (Canadian \$) in 1990-1995 to approximately \$300 million in recent years even though production has gone up. Companies plan to re-achieve original production value.
- The majority of BC brood stock originated in Ireland.
- There was consensus among all scientists and managers at the workshop that farming Pacific salmon in BC would likely cause more ecological trouble than raising Atlantic salmon.

### **Summarized Atlantic Salmon Watch Program Objectives**

- Standardize stream survey techniques
- Train samplers and crews working on streams to recognize adult and juvenile Atlantic salmon
- Involve First Nations in surveys.
- Involve Industry who put \$75K into local surveys after Sargent's Pass escape.
- Involve Research and Academic Community
- Improve the ASW
  - Determine threshold levels for action because farms can and will expand even without lifting of the moratorium.
  - Identify "at-risk" systems and concentrate effort there (systems where establishment of feral populations likely).
  - Encourage research into potential AS impacts because current knowledge makes prediction difficult.
  - Tag some salmon so that some escapees may be tracked.

### **Further Goals for the ASW:**

- Develop a coordinated decision making process usable by all program participants.
- Develop the means needed to coordinate all AS research, monitoring, information sharing and education.
- Improve consistency in data collection. Evaluate the Norwegian model.
- Submit proposals for work through the BC Research and Development Council.
- Allow other states to establish linkages to AS information through ASW
- Lobby for the resources needed to assess the magnitude and impact of AS escapes.
- Expand ASW to include all farmed salmon given these salmon's potentially large impact.
- Assist development of AS monitoring program in Washington State.
- Provide the lead in standardizing stream sampling
- Develop a training program for all involved parties including hosting of workshops/meetings.